Introduction to Cosmology
ASTR 350, 3 Credit Hours
Monday, Wednesday, Friday 1:00 - 1:50 pm -- Room 134 Astronomy
Spring Semester 2016

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Prerequisites:
The formal course prerequisites are to have one introductory astronomy course, i.e.: ASTR 100, or ASTR 121, or ASTR 122, or ASTR 210, or consent of instructor. In particular, a background in physics or calculus is NOT a course requirement. It will be possible to do all of the required coursework with only the introductory background in the prerequisites. So if you are not a science major, and/or you do not have a physics or math background, this course is meant for you. But some students with a more technical background do take this course, and enjoy it and benefit from it.

Because of the diversity of student backgrounds, the level of the lectures and class discussion cannot at every instant be tuned to the background of every student. Inevitably, there will be some moments when either the discussion is not aimed at your level. My intention is to reward your occasional patience with a degree of "customization." That is, the required materials in lecture and in the homework will all be accessible to everyone regardless of background. But I intend to make some homework assignments, as well as the entire term paper, to have optional elements that are aimed at non-science majors as well as optional elements aimed at those more familiar with physics. Thus to some degree you can choose how technical you wish the course to be.

Note for "Technophiles" = students with a more technical background: Cosmology is presented in a more quantitative and physics-based manner in the undergraduate course Astronomy 406: Galaxies and the Universe and also in the graduate course Astronomy 507: Cosmology.

Note for Astronomy Majors and Minors: this course can count as an advanced elective. Similarly, for the minor, this course will count as an advanced Astronomy course.

Recommended Text:
This book gives a modern overview of cosmology. It has the right level, i.e., not too math-heavy, and it has excellent figures that are extremely useful.
I do not follow the textbook in structuring the course or the lectures. Rather, I will present material in the manner that I find most pedagogical and, I hope, entertaining; the textbook will serve to offer an excellent alternative discussion for those times when you find my own to be unclear and/or incomplete.

Everything needed for homework and exams will be covered in lecture, but the textbook’s exposition may help you understand more difficult topics, and some questions will be drawn from it.

**Catalogue Course Description:**
Descriptive course on modern cosmological theories. Topics include aspects of special and general relativity; curved spacetime; the Big Bang; inflation; primordial element synthesis; the cosmic microwave background; the formation of galaxies and large scale structure.

Credit is not given for ASTR 350 if credit in ASTR 406 has been earned.

**Extended Course Description:**
Welcome to Introduction to Cosmology. As science on the grandest of scales, cosmology deals with the origin and development of the universe. This course will help you understand the fundamentals of cosmology, and to have knowledge of open questions, and of observational and theoretical tools. The emphasis in this course will be cosmology as a centerpiece of modern science. This course requires students to use iClickers and the course web site on Moodle (https://learn.illinois.edu/course/view.php?id=15601) to participate in discussions and retrieve assignment updates.

At this moment, cosmology is enjoying a golden age in which observation and theory come together to finally settle longstanding questions, but in doing so stumbling upon unexpected and profound new mysteries. We now have an increasingly precise understanding of the scale, shape, motion, and ingredients of the present-day universe. But in detail, we find that most of the matter in the universe must take an exotic form unlike anything found in laboratory experiments to date. This startling result points up a fundamental incompleteness in our understanding of elementary particles and their interactions. We are even more staggeringly ignorant as to the nature of the dominant constituent of the universe today, the "dark energy."

Yet despite these enormous open questions, we can already say a surprisingly great deal about the history of the universe. We have particularly precise and quantitative understanding of the formation of the most abundant elements in the cosmos and the much later quenching of the cosmic fireball. We are developing a detailed understanding of how tiny variations in cosmic matter across space grow with time to form the structured cosmos of the present day. In this course, we will survey these topics and their interrelations.

**Course Purpose:**
This course presents the fundamentals of modern cosmology. It will help you develop the skills to apply physical principles to understand observations--using the laws of nature measured here and now to reveal what happened "there and then." We will also turn the problem around, and view the universe as a laboratory for fundamental physics--using the observed properties of the cosmos to reveal the nature of matter, space, and time on both the grandest cosmic scales and the tiniest subatomic scales.
Course Intended Learning Outcomes or Learning Goals:
• Understand the fundamentals of modern cosmology by studying and reflecting on the topic
• Have knowledge of open questions in modern cosmology, and of observational and theoretical tools
• Develop the skills of applying physical principles to understand observations
• Develop the skills of using observations to critically test theoretical models

Personal Learning Goals for this Course:
Use the spaces below to list a couple of personal goals for this course. We will discuss them throughout the semester.
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Classroom Procedures:
This course requires three hours of class work each week. It will be taught using assessments, discussions, and lectures. Assignments and assessments will support students in accomplishing the intended learning outcomes.
• Assessments will consist of activities designed to evaluate your knowledge and abilities to accomplish the intended learning outcomes. There will be different types of assessments: working on homework assignments, participating in discussions, answering iClicker questions, and taking Hour and final exams. All assessments will be used for grading purposes and as a means for you to receive feedback and improve. Please take advantage of all the assessment opportunities you will have in this course by using the assessments to reflect on the depth and value of your learning.
• This course will have materials available on the Internet through Moodle. You will need to have access to the Internet to complete some assignments, such as discussions. If you do not have Internet access on a personal computer, consider using the on-campus computer labs. Check Moodle often for assignment updates and course announcements.

Participation:
Readiness to learn means that you will come to class with questions and insights to offer others and prepared to discuss the relevance and application of the course materials.

Characteristics of Students Who Excel in this Course
• Come to class with assignments finished, assigned sessions of text read, and are ready to actively engage the material
• Actively participate and respond to iClicker questions and discussion questions
• Prepare for the exams in study groups with peers

Recommended Study Habits:
Check course web site on Moodle for announcements and up-coming assignments or exams. I suggest that you form study groups to prepare for the Hour and final exams. Get the phone numbers of at least two classmates that you can contact if you have questions or need help studying.
1.
2.
**Tips on Using This Syllabus:**

- Use the intended learning outcomes to evaluate your academic progress throughout the course.
- Refer to the assignment descriptions and point values often.
- Use the recommended study habits to obtain the grade you want.

**Grading Procedures:**

Grades in this course will be based on the following assignments:

<table>
<thead>
<tr>
<th>Assignments</th>
<th>Points Possible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Participations (iClicker Questions)</td>
<td>50</td>
</tr>
<tr>
<td>Homework (best 10 of 11)</td>
<td>500</td>
</tr>
<tr>
<td>Discussion Questions (best 10 of 11)</td>
<td>100</td>
</tr>
<tr>
<td>Hour Exam 1</td>
<td>100</td>
</tr>
<tr>
<td>Hour Exam 2</td>
<td>100</td>
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<tr>
<td>Final Exam</td>
<td>150</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>1000</strong></td>
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Grades will be determined by dividing the total points earned by the total points possible. Letter grades are assigned based on the following grade breakdown.

- A = 93.6% - 100%
- A- = 90% - 93.5%
- B+ = 86.6% - 89.9%
- B = 83.6% - 86.5%
- B- = 80% - 83.5%
- C+ = 76.6% - 79.9%
- C = 73.6% - 76.5%
- C- = 70% - 73.5%
- D+ = 66.6% - 69.9%
- D = 63.6% - 66.5%
- D- = 60% - 63.5%
- F = <60%

The lower limit for each grade interval is subject to downward adjustment for the class if, in the instructor's judgement, the difficulty of the course work was too high. However, the lower limits for each interval will not be increased. In other words, you should expect that grade or higher.

**Assignment Descriptions:**

**Class Participation and iClicker Questions**

You are expected to attend lectures. I will cover material in class that will not always be in the text, and the lecture material will be included on the exam. Class time is the most valuable for you if you come prepared, and are ready to actively engage the material. To encourage your engagement, the lectures will often be punctuated by opportunities for your feedback, in the form of asking questions, voting on the possible outcomes of observations or demonstrations, or brainstorming answers to open-ended questions. To reward your participation in these activities, you will often be asked to respond via the iClicker. Either the old iClicker or the new iClicker2 will work.

Make sure to register your iClicker by Jan 27.

These participation surveys are not "quizzes" in the usual sense, in that you are not required to get all answers right. Rather, you will always get substantial credit simply by offering a scientifically reasonable response even if it is wrong (and in some cases the questions have no single correct answer, in which case all responses receive full credit). The point of this is that the survey is always an opportunity to gain points as long as you are actively engaged, even if you are still a little confused. Indeed, the most difficult and potentially confusing subjects are precisely those that most require you participation!
For each iClicker poll, 1.5 participation points will be available: the full 1.5 points will be awarded to correct response(s), while 1 point will be given for any other scientifically reasonable responses. Your total participation points will accumulate until they reach a maximum of 50 total participation points; if you faithfully attend class and answer correctly most of the time, you can reach this maximum a few weeks before the end of the semester. There are thus ample opportunities to attain this maximum score, even if several classes are missed due to situations such as late class registration, family emergencies, job interviews, and malfunctioning iClickers; therefore no additional participation opportunities will be available beyond those in each class.

You are responsible for ensuring that your iClicker points are properly credited in the Moodle gradebook. If you believe that you have not received proper credit for your iClicker responses, you must send an email detailing your situation to the TA within 48 hours of the time the grades are posted. No adjustments will be made to iClicker grades after 48 hours.

In order to receive credit for your iClicker responses, you must register your iClicker (https://learn.illinois.edu/mod/url/view.php?id=1361068), even if you have done so in a prior semester. You must have come to class at least once and voted on at least one question in order to complete this registration properly. Once you have responded to a question with your iClicker, visit the course Moodle page and click on the "iClicker Registration" link. Enter your iClicker remote ID in the required field and click Submit. If you lose or break your iClicker, you will need to purchase another one. If this happens, please email the instructor with your new remote ID so that he can manually register your new iClicker.

If you have questions about iClickers, please visit www.iclicker.com or ask the instructor or TA.

**Homework**

Eleven homework assignments will be posted and submitted via the course web site on Moodle. These are meant to sharpen your thinking on the material covered in lecture, to develop your intuition and quantitative skills, and to help prepare you for the exams. They will be due online by 1:00 pm on the due dates specified in the schedule. Late assignments will be penalized 10 points per day (and thus will not be accepted after 1:00 pm five days after the due date).

Homework submission time will be determined by the course web server’s clock. To avoid misunderstandings due to differences in clocks, you should not wait until the last minute to submit your homework. Your lowest score will be dropped from your final grade.

Homework assignments can be uploaded to the course web site in Portable Document Format (PDF). Other formats will not be accepted. If you prefer to write out your assignments longhand, you may submit them in this form provided that you scan them into PDF (most scanners come with programs that make this relatively painless). Smartphone software such as CamScanner (for Android (https://play.google.com/store/apps/details?id=com.intsig.camscanner) or Windows Phone (http://www.windowsphone.com/enus/store/app/camscanner/d991ee36-dc78-41e1-9406-0943f13c70fb)) or Genius Scan (https://itunes.apple.com/us/app/genius-scan-pdfscanner/id377672876) (for iOS) also works very well for this purpose.
You are responsible for all of the material covered on all 11 homework assignments. Thus, it is to your advantage to do all 11 of the assignments, and hand them in on time.

You are encouraged to work with partners on the homework. However, you should make sure that you understand every aspect of every problem, and you should write up and hand in your own solution. Be assured that some of the exam questions will be very similar to previous homework assignments.

Your solution should be legible and include all calculations together with explanations of what you're doing. The TA is not responsible for deciphering unreadable or unintelligible responses. You may not get any credit if you just state the final answer.

On the quantitative problems, if your final answer is obviously wrong (e.g., you find that the radius of the observable universe is 3 cm), comment. Otherwise, you may not get partial credit.

Discussion Questions
This course will include the use of a discussion board to facilitate out-of-class interaction and discussion. Access to the discussion is via the course site on Moodle (Discussion Question Forum at https://learn.illinois.edu/mod/forum/view.php?id=1361062).

On most Wednesdays, I will post a discussion question in the Discussion Question Forum. **Answers are due by midnight the next Wednesday.** Each student will be responsible for posting (by replying to the question post) at least one substantive, on-topic response to this question or to another student’s response to it. The content and correctness of these responses will not be evaluated, but they must be substantive (at least one complete sentence, and not simply, for example, "I agree with Pat") and relevant to the posted discussion topic in order to receive credit. Profanity, personal attacks, and other inappropriate posts will be deleted by the instructor and will result in zero.

Exams
There will be two in-class hour exams, and a comprehensive final exam. Exam dates and information will be posted on the course web site.

Make-up exams will be offered in well-justified circumstances, in accordance with sections 1-501 (http://admin.illinois.edu/policy/code/article1_part5_1-501.html), 1-502 (http://admin.illinois.edu/policy/code/article1_part5_1-502.html), and 3-201 (http://admin.illinois.edu/policy/code/article3_part2_3-201.html) of the Student Code (http://admin.illinois.edu/policy/code/index.html). Advance notice is required for approved school events (e.g., athletic events), religious observances, and other planned absences. Sudden illness requires documentation from McKinley Health Center or the Emergency Dean. The Emergency Dean must be contacted in other cases of unforeseen circumstances (e.g., death in the family). The format of the make-up may differ from the standard exam. In all cases, the make-up will be scheduled after the main exam.

Course Policies:
Attendance
You are expected to attend class regularly. The lectures will include material that is not in the textbook, and this supplementary material will be included in homework assignments and exams. Class participation is a part of your final grade and is measured using your iClicker responses.

**Late Work**
Assignments will be due at the beginning of class on Friday unless otherwise indicated. Assignments turned in after the due date will be penalized (refer to above for details).

**Late Course Registration**
Students considering late registration are welcome but strongly encouraged to speak with the instructor prior to joining the course.

Out of fairness, the same grading standards will be used for all students in the course, and all students will be responsible for all assignments and all lecture material. Those students who register late are welcome, but join the course with the understanding that they are responsible for the material covered before they joined the course. The policy of dropping the lowest two assignments allows late registering students to avoid penalty on any assignments missed before joining the course, as long as the remaining assignments are completed.

**Honesty:**
Academic integrity lies at the core of the University's education and research missions; accordingly, you are expected to internalize the spirit as well as the letter of the University’s rules on academic integrity (http://www.library.illinois.edu/learn/research/academicintegrity.html). Infractions of these rules — including but not limited to cheating, plagiarism, falsification of data, and grade alteration — will be penalized as provided for by Article 1, Part 4 (http://admin.illinois.edu/policy/code/article1_part4_1-401.html) of the Student Code (http://admin.illinois.edu/policy/code/index.html). Bringing a fellow student's iClicker to class or having another student bring your iClicker to class and respond on your behalf is cheating and will be dealt with accordingly.

**Guidelines for collaborative work** Discussing course material with your classmates is encouraged, but each student is expected to do his or her own work. You are allowed to work together on homework problems, but each student should write up an individual description of the solution. Some activities may allow you to work together in gathering data. Each student who participated in a joint measurement may make use of that jointly acquired data, but each student should prepare an individual report. Finally, on exams your work and your answers must of course be entirely your own. If you are in any doubt about whether something is allowed or not, ask the instructor or TA.

**Etiquette:**
For the benefit of your fellow students and your instructor, you are expected to follow these basic rules of decorum.

- Show up for class on time. If you must be late on a regular basis, please inform the instructor.
- Turn off or silence your cell phone before class begins.
- Do not leave class early, and do not rustle papers or pack up bags in preparation for leaving before class is dismissed.
- Be attentive in class. Do not use headphones, read newspapers, or prop your feet up on other chairs or desks.
• Be respectful in your interactions with your fellow students and your teachers, whether in person or in cyberspace.

Electronic devices such as laptops, tablets, mobile phones, and the like, are tools that can enhance the classroom but also can be disruptive if misused. I will allow the use of such devices in class for the purpose of taking notes only. But you are expected to pay attention in class, and these devices and be very distracting; you are expected to use them only for note-taking.

Students must respect the classroom environment. Unless specifically directed by the instructor, students shall refrain from sending email and instant messages, or from engaging in other activities (reading non-course materials, engaging in private conversations and so on) that disrespect the classroom environment and learning conditions for others.

Disruptive behavior and/or misuse of electronic devices can affect your participation grade for that day. If the behavior continues, there will be additional reduction in the overall course participation grade.

**Accessibility:**
To insure that disability-related concerns are properly addressed from the beginning, students with disabilities who require reasonable accommodations to participate in this class are asked to see the instructor as soon as possible. All accommodations will follow the procedures given in sections 1-107 (http://admin.illinois.edu/policy/code/article1_part1_1-107.html) and 1-110 (http://admin.illinois.edu/policy/code/article1_part1_1-110.html) of the Student Code (http://admin.illinois.edu/policy/code/index.html).